A Dynamic Forecasting Model for the Finnish Pulp Export Price

Anne Toppinen, Susanna Laaksonen and Riitta Hänninen

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This study investigates the relationship between Finnish sulphate pulp export prices and international pulp inventories using the Johansen cointegration method. Long-run equilibrium is found to exist between pulp price and NORSCAN inventory for the study period, 1980–94. Granger causality is found to exist from inventory to price but not vice versa. A simple short-run forecasting model for the Finnish pulp export price is formed. In preliminary analysis, the explanatory power of model is found to be acceptable but only under stable market conditions.

Keywords pulp, price, inventory, business cycles, cointegration
Authors' address Finnish Forest Research Institute, Helsinki Research Centre, Unioninkatu 40 A, FIN-00170 Helsinki, Finland **Fax** +358 9 8570 5717 **E-mail** toppinen@metla.fi
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1 Introduction

The Finnish economy is heavily dependent on forest industry exports. During the last decade over 35 per cent of Finland's export income was generated by the forest industry. Pulp and paper alone account for over 80 per cent of total export income from the forest industry. The Finnish pulp and paper industry has experienced a structural change since the 1970s, so that the export share of highly converted paper and paperboard products has increased substantially while the share of bulk products, such as pulp and newsprint, has declined. For example, in 1980 the exported share of sulphate pulp in the chemical forest industry was around 40 per cent, whereas in 1994 only about one-quarter of Finnish pulp output was exported. Finnish pulp is exported primarily to Western Europe, to production units owned by Finnish forest industry companies, and thus the share of pure market pulp in pulp exports is low.

Historically, pulp prices have fluctuated widely, as is typical for raw materials and intermediate products. The price of pulp is significant for the whole forest industry in that it reflects strongly to both paper prices and the profitability of forest industries. Hence, pulp price is one of the variables that could serve as a general indicator of business cycles for the forest sector. Accurate forecasting of pulp prices would therefore be useful to economists at both the industry and economy level.

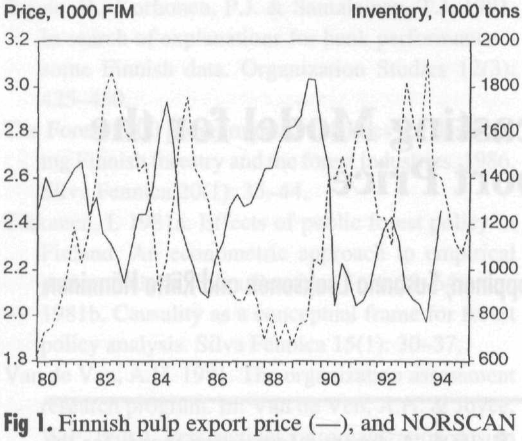

Fig 1. Finnish pulp export price (—), and NORSCAN pulp inventory (…) 1980–95:2.

Pulp price seems to be tied closely to pulp inventories, as the graph of the time series in Fig. 1 indicates. Empirical time series analysis verifies the strong negative correlation between price and inventory data. Inventory fluctuations lead price fluctuations by one quarter if measured by the highest simple cross-correlation coefficient (–0.76) between current price and one-period lagged inventory.

There are numerous studies concerning forest product prices or inventory behaviour, but few specifically consider the relationship between pulp price and inventories. Of the earlier work, we might mention Luppold (1984), who studied the U.S. hardwood lumber markets. The most recent study is by Lewandrowski et al. (1994). This study examines the role of finished product inventories and price expectations in production, sales and inventory decisions in the U.S. softwood lumber industry. Pulp prices and inventory fluctuations were considered in Hösteland (1978) and cyclical dumping of Canadian market pulp in Brännlund and Löfgren (1995).

Few econometric studies of Finnish pulp industry exports have been done. Finnish exports of pulp and paper to the United Kingdom are considered in Havukainen (1976) and to the United Kingdom and Germany in Laaksonen and Toppinen (1994). Tervo and Toppinen (1992) considered the cyclical indicators for pulp and paper industry export quantities, but export prices were not included in the study.

The aim of the present study is to investigate the extent to which pulp inventories are helpful in forecasting pulp prices, both in the short- and long-run. In the empirical section, fluctuations in quarterly time series on inventories and prices of chemical sulphate pulp are analyzed. Further, a simple dynamic error correction model, following Engle-Granger (1987), is formed by using the long-run cointegrating vector obtained by the Johansen method (Johansen 1988, Johansen and Juselius 1990). The forecasting properties of the model both in and outside of the sample are discussed.

2 Economic Model

A typical approach in modelling price and inventory behaviour is to start with the firm's profit maximization problem, assuming linear demand and quadratic production and inventory holding costs. This kind of a linear-quadratic model is used in forest sector models for example by Lewandrowski et al. (1994). The model produces first order conditions indicating that expected price equals marginal cost, and that the expected benefit of holding one more unit in the end-of-period inventory equals the expected cost of holding inventory. However, for our forecasting purposes, a simpler model is constructed including only prices and inventories.

In this study, we assume that there is a single risk-neutral firm producing in each period a single good, pulp. We assume that a firm, i.e. here a Finnish exporter of sulphate pulp, takes the international market price as given and that Finland's price equals the world market price. Consequently, Finnish exporters are able to adjust their quantity supplied in order to obtain the economically optimal production level and their individual actions have no influence on the current or future price levels.

If the international demand for pulp starts to increase and pulp exporters' production does not react immediately or sufficiently, the inventories are first used to fulfil the increased demand. When the inventory level has declined and demand is still increasing, the market price of pulp starts to rise, other things equal. So, a decrease in the inventory level indicates an increase in the international and Finnish price and therefore we expect that the coefficient of inventory in the price forecasting model to be negative.

3 Data and Methods

In our empirical analysis, we use quarterly data for the period 1980–94 (T = 60). Price data would be available also on a monthly basis but inventory data are not. Considering the arbitrage in the pulp market, quarterly data seems in any case to be the most appropriate. In the model estimation, the last four data points were left out in order to test the model's out-of-sample forecasting properties.

Average export unit value for chemical sulphate pulp exported from Finland, 1000 FIM/ton, is used as a proxy for pulp price, because it is obtainable from public sources (Customs statistics of Finland). Real price is calculated by deflating the export unit value of pulp by the producer price index for Finland's industrial branch 34 (pulp and paper industry). The cointegration analyses were conducted also for the Finnish pulp price converted into U.S. dollars, but the test results turned out to be the same as with the FIM price. For an inventory variable, the total NORSCAN region (including Canada, USA, Finland, Sweden and Norway) softwood market pulp inventories at the beginning of the period are used. The source of this data is the Pulp and Paper International magazine for various years.

Inventory is used as the only explanatory variable in forecasting pulp price, which is a limitation to the model. Unfortunately, other variables that could be influential, e.g. the pulp industry factor input prices or the capacity operating rate for the pulp (paper) industry representing tightness of supply (demand) conditions, were not readily available for the study period.

In economic time series analysis, unit root econometrics and, especially, the concept of cointegration, have become central issues over the last decade. Introduced by Engle and Granger (1987), cointegration is a statistical property of data that can describe the long-run co-movement of economic time series. If cointegration is found to exist between a certain set of economic variables, an error-correction model could be formulated incorporating both the long-run and short-run effects. During the 1990's Johansen's multivariate cointegration estimation methodology (Johansen 1988, Johansen and Juselius 1990) has also become very commonly used in applied work.

Johansen's method uses vector autoregression in estimating the unrestricted p-dimensional VAR model

$$\Delta x_t = \Gamma_1 \Delta x_{t-1} + \ldots + \Gamma_{k-1} \Delta x_{t-k+1} + \Pi x_{t-k} + \mu + \Phi D_t + \varepsilon_t, t = 1, \ldots, T \qquad (1)$$

The constant term μ can be restricted to the cointegrating space to represent no linear trend in the data. Seasonal dummies D can be included in the analysis when using quarterly data. Introducing sufficient lags k is necessary to get a well-behaved error term of NID(0, Ω). Assuming that $X_t \sim I(1)$, i.e. assuming that the series are integrated of order one, the components of X_t are cointegrated when the rank r of impact matrix Π is greater than zero but less than p. When r equals zero, the variables are not cointegrated. When the rank r is full, i.e. r equals p, the variables are stationary by themselves and the normal statistical inference applies. The rank of the long-run matrix $\Pi = \alpha\beta'$ determines the number of cointegrating vectors. The rows of matrix $(r \times p)$ β' are the stationary cointegrating vectors and columns of matrix $(p \times r)$ α give the weights with which the error-correction terms enter each equation.

Johansen (1988) derives two likelihood ratio-tests for measuring the number of cointegrated vectors. The trace test for testing the rank of cointegrating matrix is calculated as

$$-2\ln(Q) = -T \sum_{i=r+1}^{p} \left(1 - \hat{\lambda}_i\right) \qquad (2)$$

where Q is an indicator for the quadratic canonical correlations associated with matrix Π, T refers to the number of observations and λ to the estimated eigenvalues. The null hypothesis is H_0: rank $(\Pi) \leq r$ and the H_1 hypothesis is that the number of cointegrating vectors is larger than r. Another version of the test, the maximum eigenvalue test λ_{max} is similar except that the alternative hypothesis is that the number of cointegrating vectors equals r.

The main advantage of Johansen's procedure, besides its ability to test for the existence of multiple cointegration vectors, is the possibility using χ^2 distributed likelihood ratio tests for various linear restrictions on the cointegration space. For example, tests for weak exogeneity and variable exclusion can be formulated under a certain cointegration rank with zero restrictions on the α or β matrices. If the hypothesis $\beta'\alpha = 0$ (i.e. that the row of loadings is restricted to zero) can be accepted, then the variable ΔX_t is weakly exogenous to long-run parameters α and β. It is also possible to test the null hypothesis of stationarity of a variable in cointegration space with the linear restriction on the cointegration space (more in Johansen and Juselius 1992).

Granger causality tests are used here to measure whether international pulp inventories can be used to improve the autoregressive forecasts of Finnish pulp price. Essentially, the Granger causality testing (e.g. Granger and Newbold 1986) involves using F-tests to determine whether the lagged values of a variable, say X, make any statistically significant contribution to explaining Y_t, in addition to the lagged Y_{t-j}. Thus, one is testing the joint significance of c_j in

$$Y_t = a + \sum_{i=1}^{j} b_i Y_{t-j} + \sum_{t=1}^{j} c_i X_{t-j} + u_t \qquad (3)$$

where H_0: $\Sigma c_j = 0$. The procedure is applied also in the opposite direction, from Y to X. If Granger causality proceeds in both directions simultaneously, there is feedback between the variables.

The forecast equation is estimated in the following error-correction form using first differences of the variables in logs:

$$ln\,\Delta\,PSFA_t = c + b_1\,\Delta\,ln\,NORSCAN_t + b_2 ECT_{(t-1)} + e_t \qquad (4)$$

where $PSFA$ is Finnish pulp price, $NORSCAN$ is international inventory quantity, c is the constant term and ECT is the error-correction term obtained from the Johansen cointegrating regression. The econometric model is estimated using PCFIML 8.0 software for Johansen cointegration analysis. Diagnostic test statistics available in PCGIVE, i.e. for residual autocorrelation (DW and RAC-tests), heteroscedasticity (ARCH-test), and parameter constancy (Chow-forecast test), are employed in model evaluation and testing for forecasting performance. More about the use of misspecification test procedures can be found e.g. in Greene (1993) or Doornik and Hendry (1994).

4 Results

Results from both Johansen's trace and maximum eigenvalue tests in Table 1 indicate cointegration between price and inventory with one lag in the test equation but not for any longer lag structure. As the residuals of the two-variable system behave well, the use of only one lag in cointegration analysis seems justified. The estimated equilibrium vector β_1 between pulp price

Table 1. Johansen cointegration test (p = 2, k = 1, restricted constant).

Null hypothesis $r \le i$	Eigen-values λ	Test statistics trace	λ_{max}	Critical values trace / λ_{max} (95 %)
$r \le 0$	0.31	27.57*	20.28*	20.0 / 15.7
$r \le 1$	0.12	7.28	7.28	9.2 / 9.2

Table 2. Estimated eigenvectors β_i and the corresponding α_i-weights.

(r = 1)	Eigenvectors β_1	β_2	Weights α_1	α_2
Pulp price	**1.00**	–6.68	–0.34	0.006
Inventory	**0.41**	1.00	0.02	–0.05
Constant	**–3.80**	–1.50		

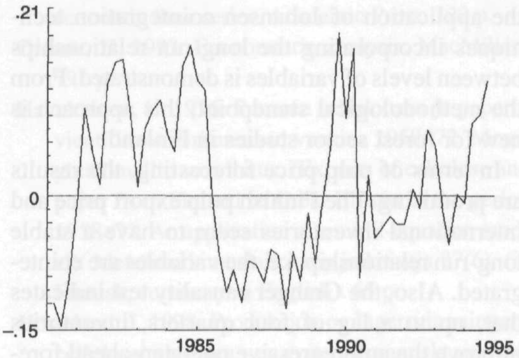

Fig. 2. Cointegrating vector between Finnish pulp price and NORSCAN-inventory.

level and NORSCAN inventory is given in Table 2 and it is also shown in Fig. 2. The long-run coefficient of inventory, –0.41, is the respective term β_{21} in the first cointegration vector in Table 2.

The stationarity of both the variables is tested under the hypothesis of rank one and the null hypothesis of stationarity can be rejected for the both (Table 3). The result is also supported by the standard Augmented-Dickey-Fuller unit root test (not reported here). The weak exogeneity test is performed by the zero restriction on the α-matrix. This hypothesis can be accepted for the inventory, whereas for the price it is rejected. The weak exogeneity of inventories to long-run parameters indicates that inventories are not affected by the Finnish price.

Also, Granger causality tests in Table 4 indicate significant causality running from pulp inventory to price when using lags up to four, whereas from price to inventory the causality is absent. The result is found to be robust for the use of either levels or first differences of variables. Hence, pulp inventories improve the autoregressive one-step-ahead price forecast, but feedback does not exist from price to inventory.

The explanatory power of the model is moderate as measured by the adjusted R^2, but the inclusion of a single dummy for the third quarter of 1990 increases it substantially, to 0.61 (Table 5). This outlier observation could also be seen from the recursive residual of the model without a dummy, where the timing of the latest recession

Table 3. Stationarity and exogeneity tests of individual time series.

	Stationarity test[1)]	Exogeneity test[1)]
Price	12.45*	11.42*
Inventory	9.57*	0.008

1) $\chi^{2(1)}$ 3.84 at 5 % level and * indicates the rejection of null hypothesis.

Table 4. Granger-causality tests using 1 and 4 lags. Probability values (in parenthesis) are for rejection of null hypothesis of non-causality.

	Price => Inventory	Inventory => Price
F-value (1)	2.39 (p = 0.13)	11.70 (p = 0.001)
F-value (4)	1.41 (p = 0.25)	2.76 (p = 0.04)

Table 5. Dynamic short-run forecasting model for pulp price 1980:1–1994:4 excluding last 4 observations for forecasting test.

	Short-run model
Constant	0.00 (0.67)
D(NORSCAN)	–0.14 (–4.04)
ECT(-1)	–0.25 (–4.13)
d903	–0.22(–5.37)
R^2	0.61
F(3,50)	25.86
DW	1.51
RAC (4)	0.97
ARCH(4)	0.50
Forecast Chow (4,50)	3.27

in the pulp market in 1990 produces a significant peak. The impulse dummy variable also eliminates significant non-normality of the residual term. Several diagnostic test results presented below the coefficients indicate that there are no significant in-sample diagnostic problems in our model.

In the forecasting equation for pulp price in

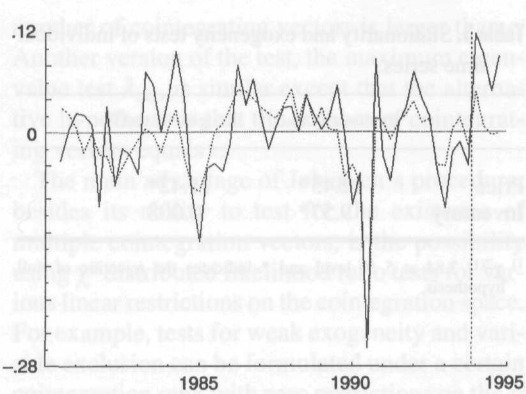

Fig 3. Actual (—) and fitted (...) values of short run model for Finnish pulp price.

first differences, the coefficient of inventory is significant and the relationship between price and inventory is negative, as expected. The lagged error-correction term is also negative and significant, thus also justifying the use of the error-correction model. The absolute value of the lagged cointegrating vector, –0.25, indicates that the adjustment to long-run equilibrium would take place in approximately one year.

The out-of-sample forecasting performance of the model for the year 1994 can be evaluated from the Fig. 3, where both the actual and fitted values of the model can be seen. Unfortunately, the short-term forecasting model clearly underestimates the pulp price rise. Also, the Chow-test for the year 1994 slightly rejects the model's out-of-sample forecasting performance. Reasons for this could be explored, e.g. in the unexpectedly fast recovery in pulp export demand, but that is beyond the scope of this work.

5 Discussion

The aim of the present study was to investigate the possibilities of forecasting Finnish pulp export prices both in the short- and long-run. Pulp price developments interest economists, as the pulp price is surely one of the general business cycle indicators of the forest sector. A simple dynamic model is therefore developed for the Finnish export price of sulphate pulp. Further, the application of Johansen cointegration techniques incorporating the long-run relationships between levels of variables is demonstrated. From the methodological standpoint, this approach is new for forest sector studies in Finland.

In terms of pulp price forecasting, the results are promising. The Finnish pulp export price and international inventories seem to have a stable long-run relationship, i.e. the variables are cointegrated. Also, the Granger causality test indicates that, up to a lag of four quarters, inventories improve the autoregressive one-step-ahead forecast of pulp price.

According to the results, moderate price changes can be well explained by changes in the inventory level and the equilibrium vector between price and inventory. However, the model is too crude for forecasting the cyclical turning points in pulp price during the research period. Further work in forecasting the business cycles of pulp industry should be extended e.g. to incorporate information on pulp export demand conditions.

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